

MEMORANDUM
REPORT NO. 634-029
February 20, 1963

TO : Head, System Evaluation Branch

FROM : Head, Magnetic Test Section
Test and Evaluation Division

SUBJECT: ARIEL Satellite (S-51 Prototype) Magnetic Tests

A series of magnetic tests were made of the AERIEL-1 (S-51 Prototype) satellite at the U.S. Naval Ordnance Laboratory Magnetic Test Facility on December 4-7, 1962. The purpose of these tests was to obtain data to indicate the probable magnitude of the magnetic moment of the S-51 flight unit which is presently in orbit. This information has been requested by Dr. A. P. Willmore of University College, London, England for use in attempting to explain the variation of the solar aspect of the AERIEL-1 satellite.

In general, the net magnetic moment of a satellite is composed of contributions from the following four effects:

1. Permanent magnetization of ferrous materials.
2. Induced magnetization of ferrous materials.
3. Stray field due to flow of internal direct currents.
4. Eddy current fields due to voltages generated in conducting material when spun in the earth's magnetic field.

Data has been obtained to indicate the magnitude of the moment due to the first three effects. No experimental investigation has been attempted of the fourth effect, but it is believed to be small due to the low rate of spin and the absence of large areas of conducting material.

Data was obtained by two methods; 1) magnetic detector moved past below the stationary satellite, and 2) satellite moved past along side of the stationary magnetic detector.

1 of 14

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The detector is a triaxial fluxgate magnetometer operating at a sensitivity of one gamma per tenth inch division. Figures 1 and 2 are photographs of the satellite mounted in the test facility. Figure 3 is a diagram of the test arrangement for Method 1.

A survey was made of the vertical component (H_z) of the magnetic field three and one-half feet below the approximate center of the satellite. The large facility coil system was in operation such that the earth's field was compensated to zero (within 0.1%) over the entire volume of the satellite. Thus the field measured is that due to the permanent magnetization only. A contour map of these data is shown in Figure 4. A study of this map indicates that the permanent moment is predominantly vertical, directed upward, but tipped about ten degrees to the south and ten degrees to the west. (These are geographic rather than geomagnetic directions since the earth's field was compensated to zero.)

It should be noted that the solar paddles were not on during this test due to physical limitation of the test rig. A later test of an isolated paddle indicated that the permanent moment of each paddle would contribute about 13 gamma at a distance of nine inches. The two instrument booms were in place, but the inertial booms were left off since they contained no ferrous material. Based upon this H_z data alone, the vertical moment has a magnitude of $\frac{30 \times 3.5^3}{2} = 642 \text{ gamma-foot}^3$.

By turning off the vertical axis facility coil, a measurement was obtained of the H_z field due to the vertical induced moment of the satellite for an applied field of 53,000 gamma. As shown in Figure 5, this was found to be 41 gamma at a distance of three and one-half feet (test 55 minus test 35) and indicates an induced moment of 877 gamma-foot³.

A second series of runs were made in which the three orthogonal components were measured and the total field was computed for the centerline profile. This was done for conditions of battery power OFF and battery power ON. See Figure 6.

	<u>TOTAL FIELD IN GAMMA</u>	<u>VERTICAL MOMENT GAMMA-FOOT³</u>
Power OFF	43.2	924
Power ON	47.7	1020

(measured at three and one-half feet below center)

The next set of data was obtained by the second method of measurement, i.e., satellite moved past stationary detector. Figure 7 is a diagram of the arrangement used. See also the photographs of Figure 1a and 1b. Again the three orthogonal components were recorded, but at a distance of two and one-half feet, and from these the total field was computed. This was done with paddles in place and for conditions of power OFF and power ON with two paddles activated with pairs of Sylvania sun guns, producing 520 to 530 milliamperes of charging current. The results were as shown in Figure 8 and in the following table:

	<u>TOTAL FIELD IN GAMMA</u>	<u>MOMENT GAMMA-FOOT³</u>
Power OFF	49.4	385
Sun Gun OFF		
Power ON	61.0	475
Sun Gun ON		

(measured at two and one-half feet west of spin axis)

Data from a previous test performed at the Fredericksburg Magnetic Observatory by Clell Searce indicated that one might expect about two gamma stray field normal to the paddle at a distance of two feet when the paddle is producing 500 milliamperes.

In addition, component data were obtained (by the second method) of the fields due to the permanent plus the induced vertical magnetization and due to the permanent plus the induced horizontal magnetization of the satellite. From these data the total field was computed and is shown in Figure 9. By subtracting the 0-0-0 curve from the 0-4000-0 curve one finds

the total field due to the induced horizontal moment to be 101 gamma at a distance of two and one-half feet west of the satellite. Based upon this value the induced horizontal moment is computed to be 789 gamma-foot³.

It should be noted that these data are from the S-51 prototype and do not necessarily indicate the magnetic moment of the S-51 flight unit. The permanent moment especially may vary considerably since it is closely related to the exact magnetic history of the particular satellite.

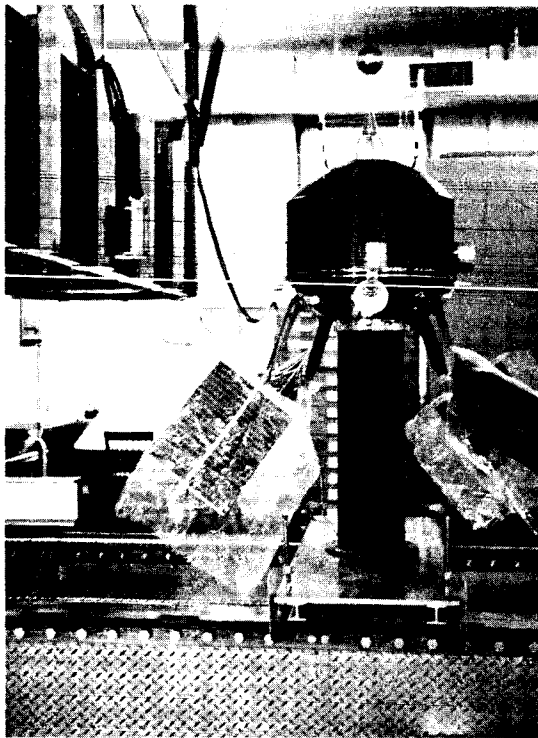


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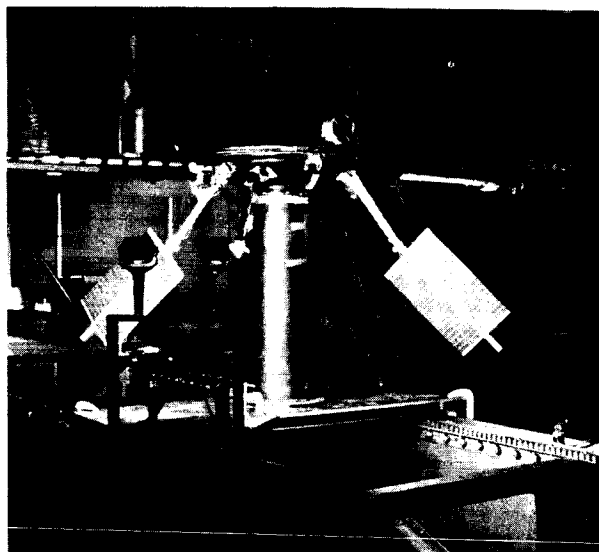
CLP:lhs

Enclosures - Figures 1-9

cc: Chief, Technical Services (L. Winkler)
Chief, Test and Evaluation Division (J. C. New)
Head, Electronics Test Branch (P. Yaffee)
Mechanical Systems Branch (R. C. Baumann)
Mechanical Systems Branch (J. T. Shea)
Mechanical Systems Branch (Ton L. Eng)
System Evaluation Branch (W. Hord)

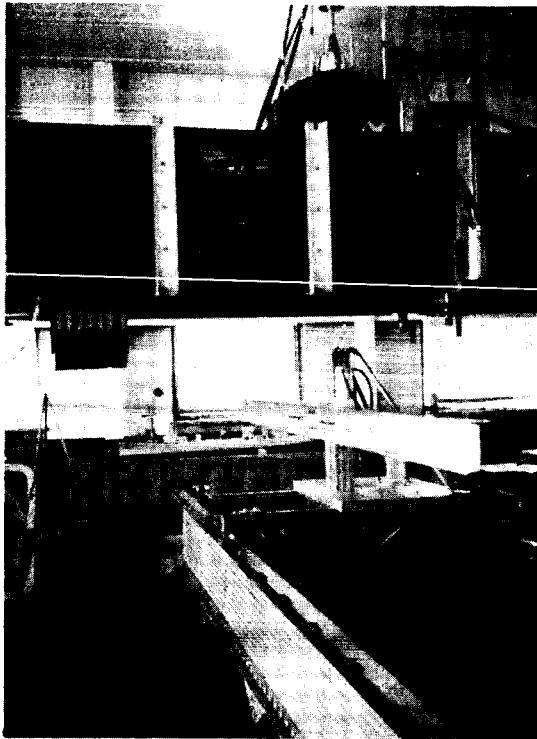


(a) Photograph of arrangement for Tests 8 thru 20 & 28 thru 31

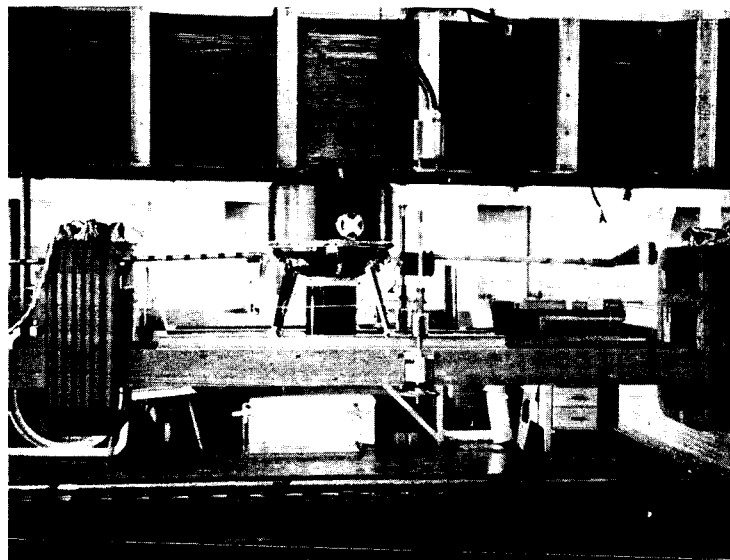


(b) Photograph of arrangement for Tests 57 thru 65

Figure 1



(a) Photograph of arrangement for Tests 35 thru 54



(b) Lowered for removal, post Test 54

Figure 2

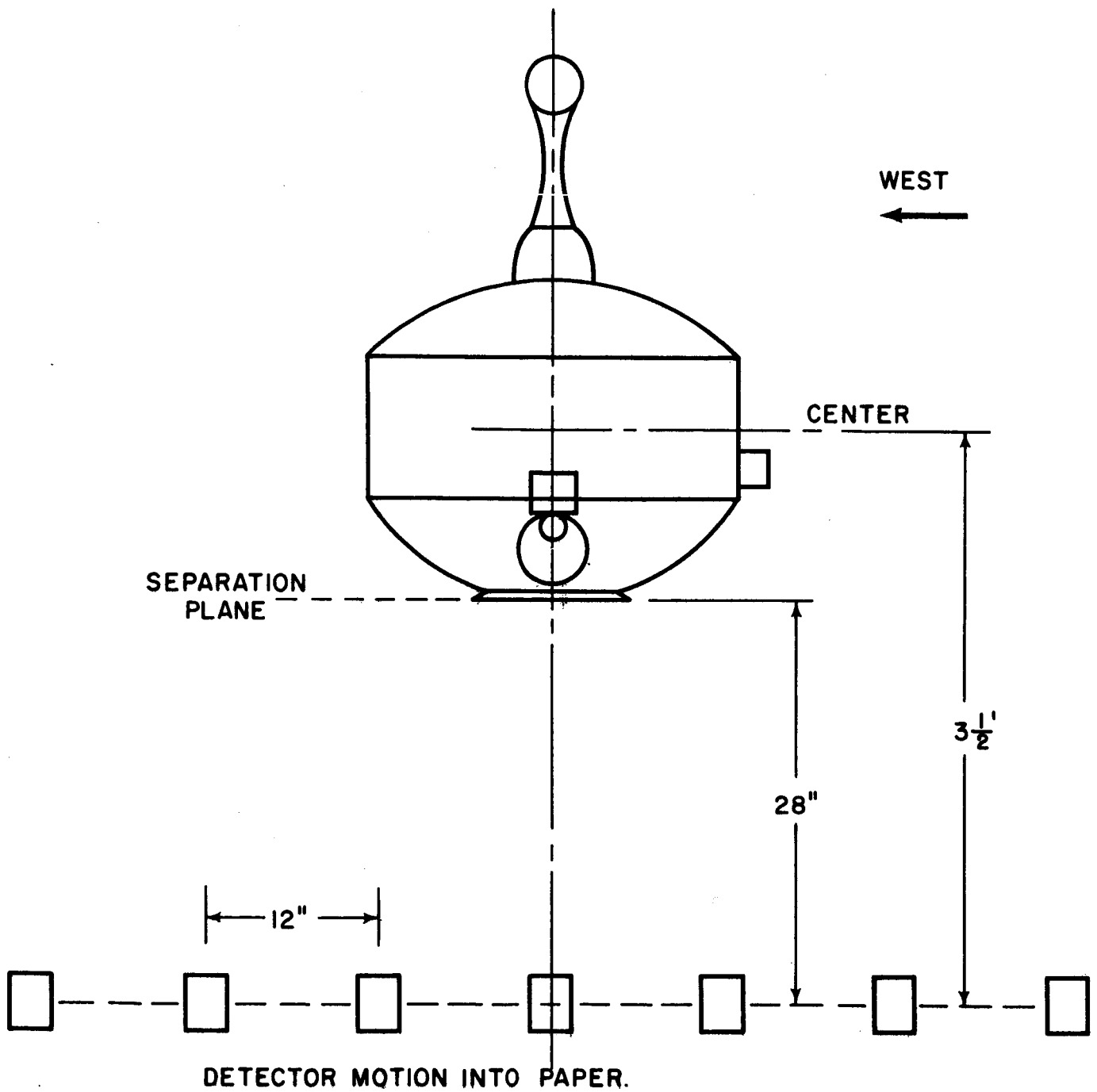


Figure-3. Arrangement for Tests 35 thru 55

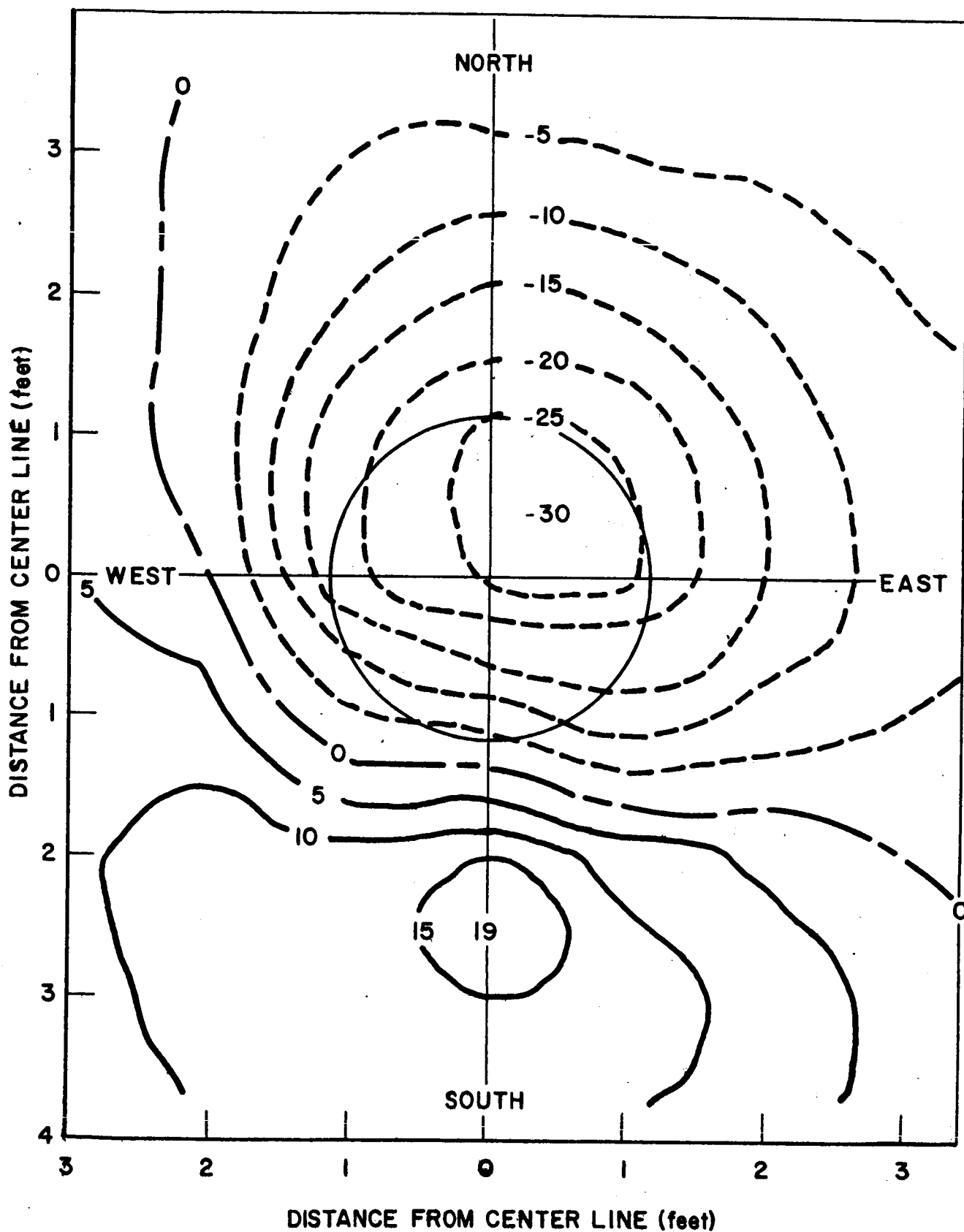


Figure-4. Vertical Component of Magnetic Field (in gamma)
3 1/2 feet below Satellite due to Permanent Magnetization

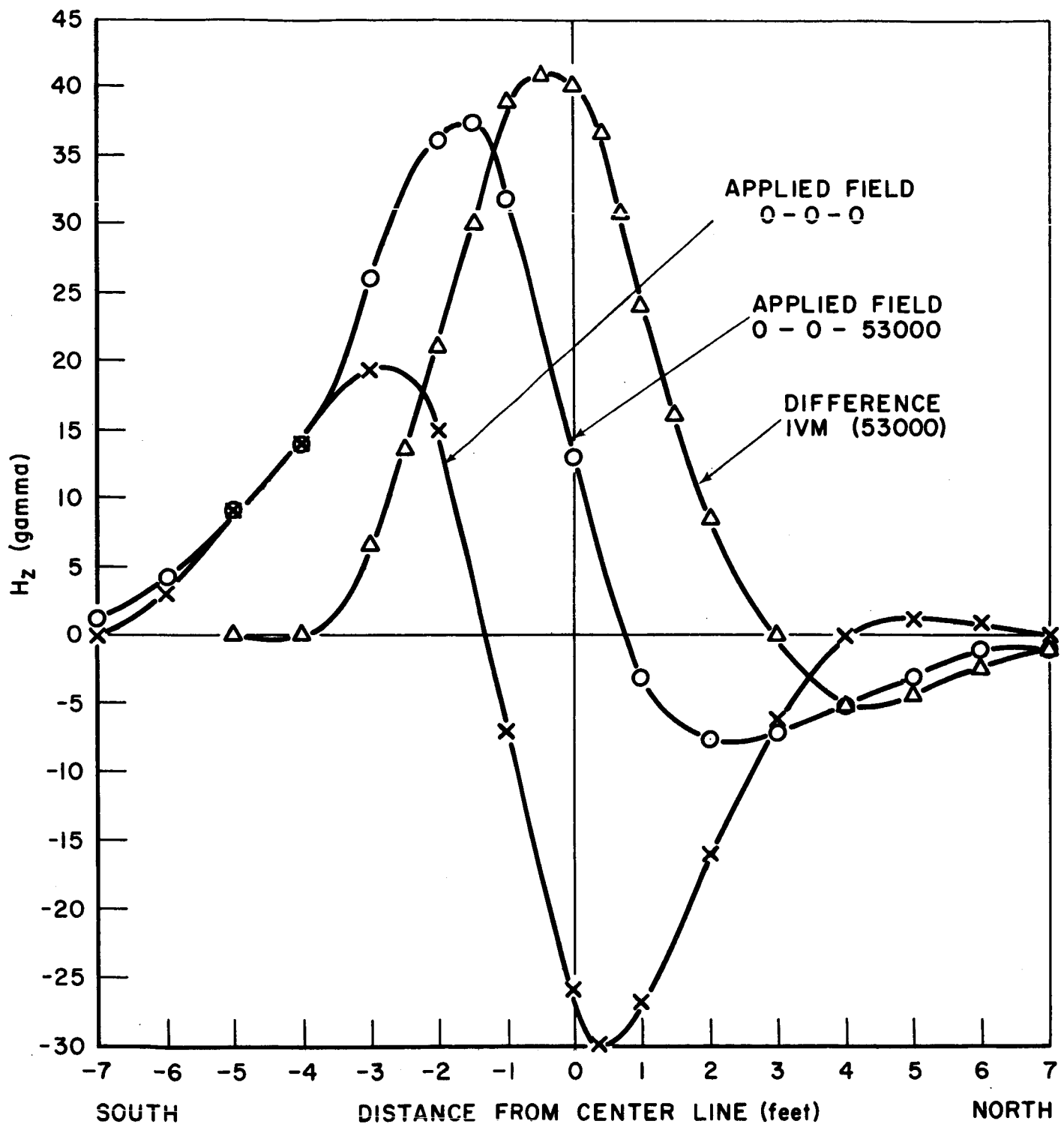


Figure-5. Vertical Component of Magnetic Field 3-1/2 Feet below Satellite due to Induced Vertical Magnetization plus Permanent Magnetization.

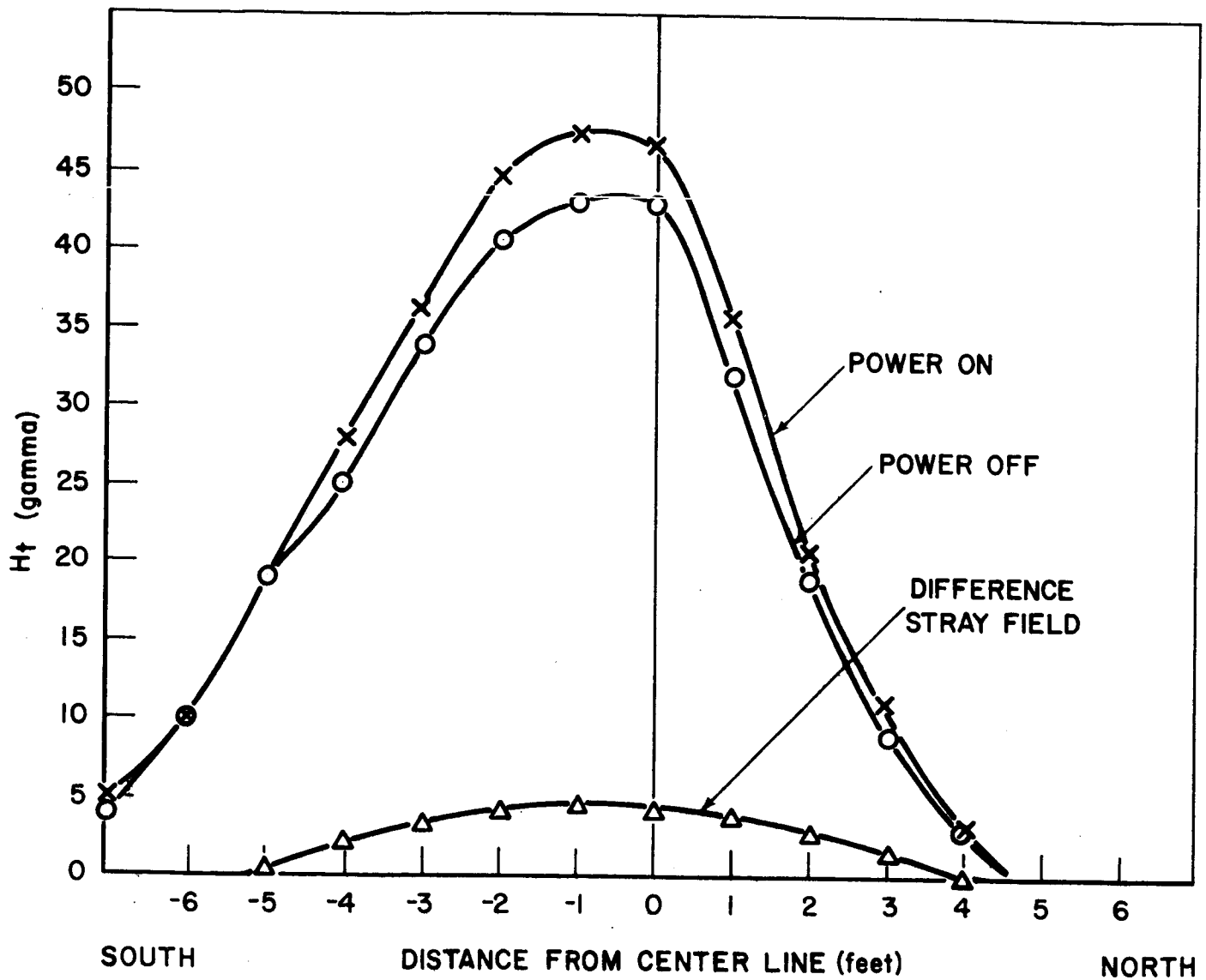


Figure-6. Total Magnetic Field $3\frac{1}{2}$ feet below Satellite due to Permanent Magnetization plus Stray. Measured in zero applied field.

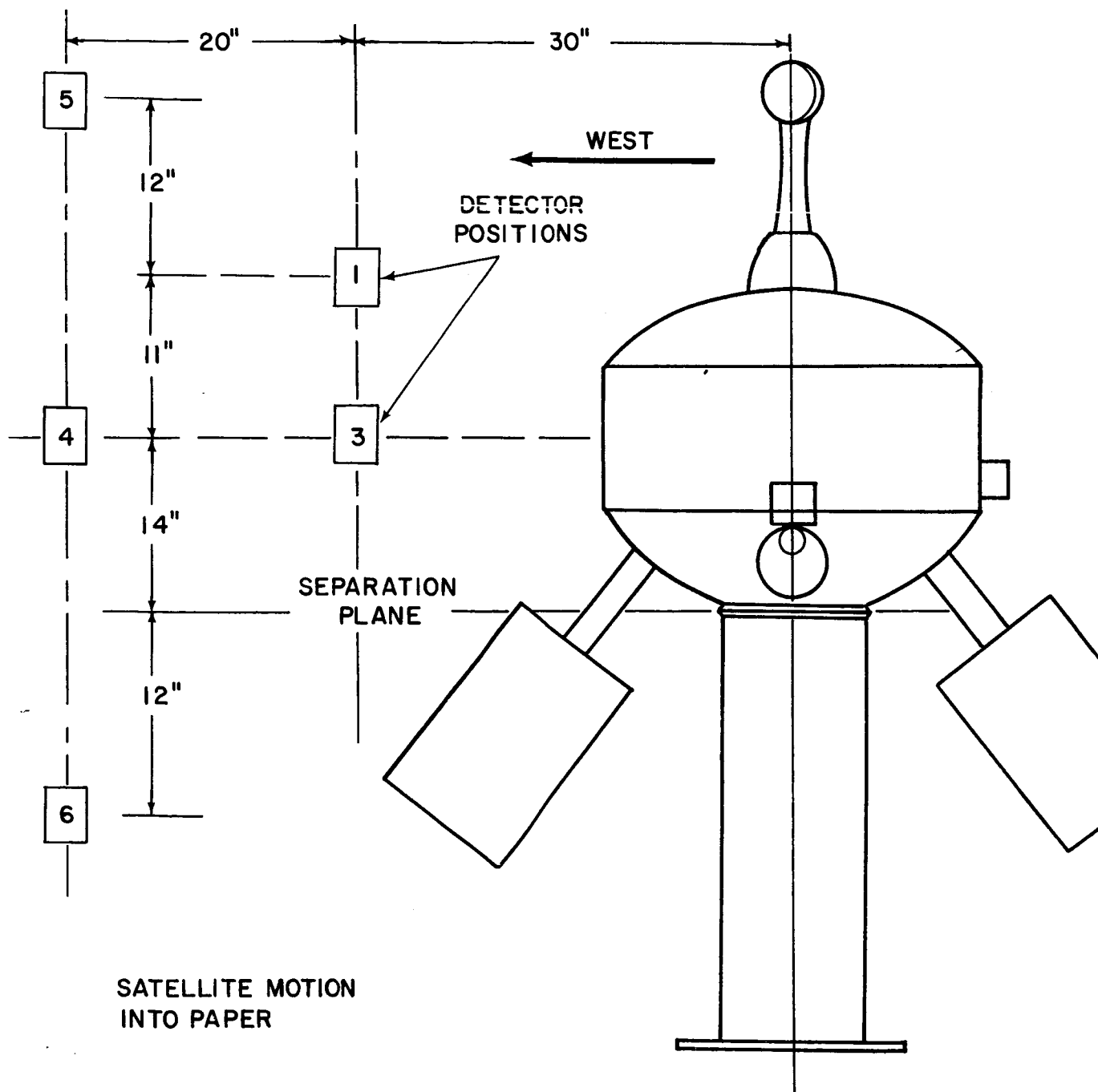


Figure-7. Arrangement for Tests 1 through 34 & 56 Through 74

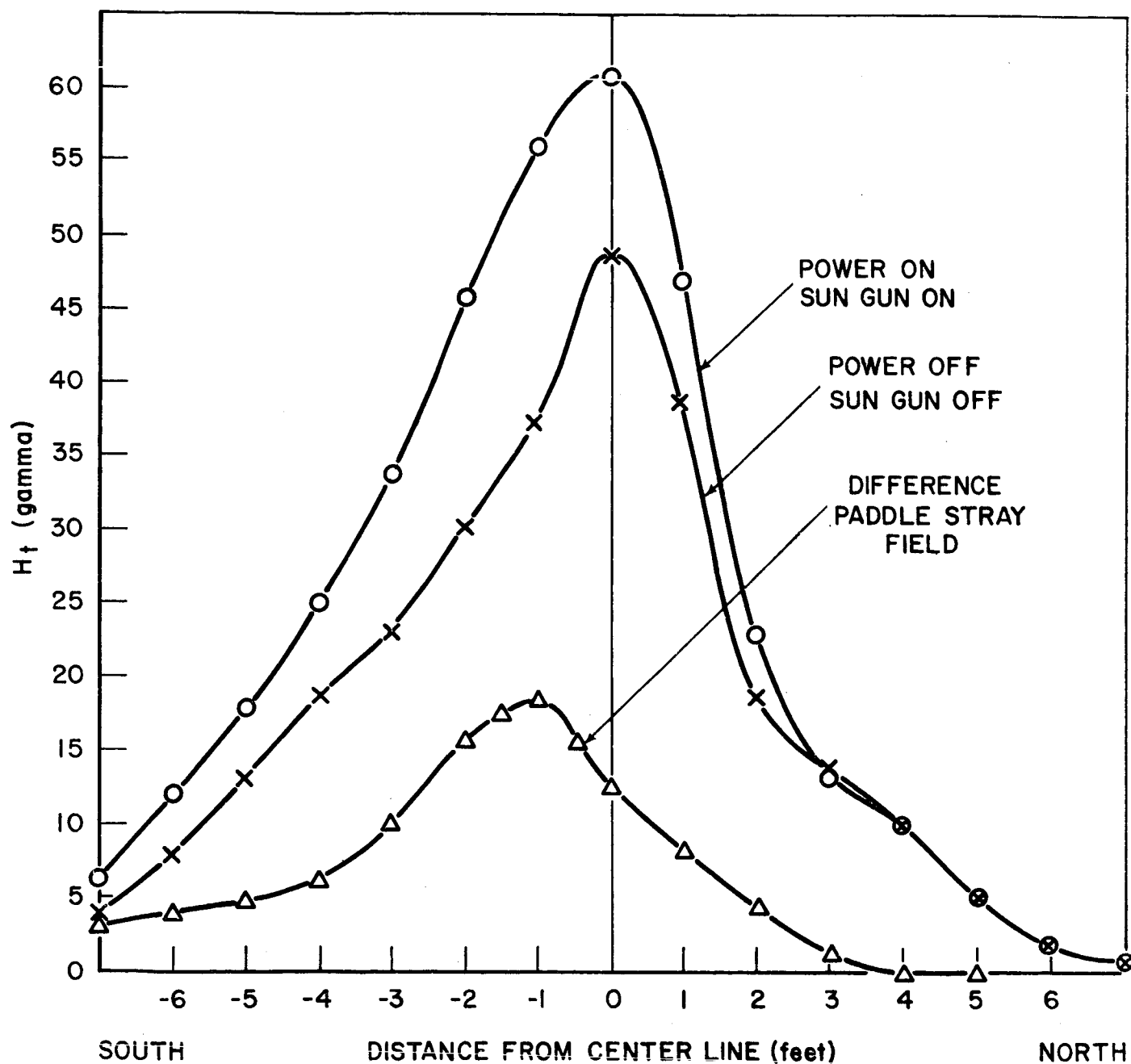


Figure-8. Total Magnetic Field $2\frac{1}{2}$ feet west of Satellite due to Permanent Magnetization plus Stray. Measured in zero applied field.

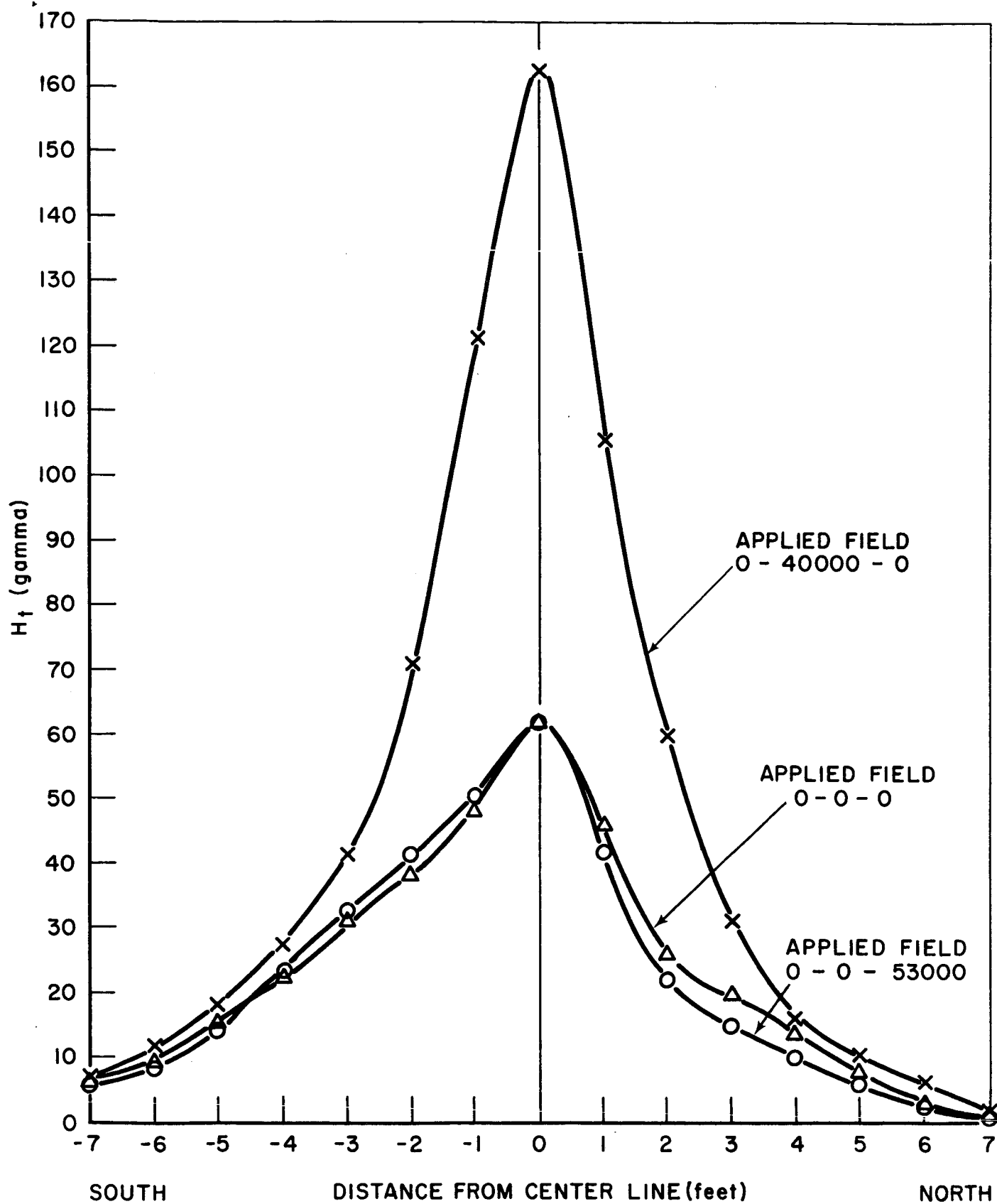


Figure-9. Total Magnetic Field $2\frac{1}{2}$ Feet West of Satellite

Table 1
Summary Of Magnetite Test Data For S-51 Ariel

Test No.	Detector Position No.	Applied Field (gamma) N-E-D	Field Measured		Detector Position (feet)		Figure No.	Remarks
			Component	Magnitude (gamma)				
				Pos.	Neg.	West	Below	
1-7	3	0-0-0	Hy	—	—	—	—	Invalid preliminary runs
8	3	0-0-0	Hx	14	14	2½	0	Booms on, paddies on, power off
9	3	0-0-0	Hx	44	8	2½	0	
10	3	0-0-0	Hy	15	56	2½	0	
11	3	0-40K-0	Hx	5	17	2½	0	
12	3	0-40K-0	Hx	93	36	2½	0	
13	3	0-40K-0	Hy	17	161	2½	0	
14	3	0-0-53K	Hx	0	30	2½	0	
15	3	0-0-53K	Hy	14	50	2½	0	
16	3	0-0-53K	Hx	38	8	2½	0	
17-34	3	0-0-53K	—	—	—	2½	0	Repeat runs; bad drift
35	7	0-0-0	Hx	20	30	0	3½	Booms on, paddles off, power off
36	7	0-0-0	Hx	12	27	-1	3½	
37	7	0-0-0	Hx	8	16	-2	3½	
38	7	0-0-0	Hx	2	8	-3	3½	
39	7	0-0-0	Hx	14	21	1	3½	
40	7	0-0-0	Hx	13	2	2	3½	
41	7	0-0-0	Hx	9	2	3	3½	
42	7	0-0-0	Hx	16	32	0	3½	
43	7	0-0-0	Hx	38	0	0	3½	
44	7	0-0-0	Hy	0	19	0	3½	
45	7	0-0-0	Hx	21	34	0	3½	Booms on, paddles off, power on
46	7	0-0-0	Hx	42	0	0	3½	
47	7	0-0-0	Hy	0	19	0	3½	
48-54	7	0-0-0	Hy	—	—	0	3½	Background changed
55	7	0-0-53K	Hx	37	7	0	3½	
56	3	0-0-0	Hy	12	58	2½	0	2 paddles on, power on, sun on, cloth on
57	3	0-0-0	Hy	11	58	2½	0	2 paddles on, power on, sun on, cloth off
58	3	0-0-0	Hx	41	12	2½	0	
59	3	0-0-0	Hx	10	9	2½	0	
60	4	0-0-0	Hy	3	14	4½	0	
61	4	0-0-0	Hx	6	4	4½	0	
62	4	0-0-0	Hx	2	2	4½	0	
63	6	0-0-0	Hy	4	5	4½	2½	
64	6	0-0-0	Hx	8	0	4½	2½	
65	6	0-0-0	Hx	3	3	4½	2½	
66	6	0-0-0	Hy	4	3	4½	2½	2 paddles on, power off, sun off, cloth off
67	6	0-0-0	Hx	7	0	4½	2½	
68	6	0-0-0	Hx	4	2	4½	2½	
69	4	0-0-0	Hy	4	9	4½	0	
70	4	0-0-0	Hx	13	0	4½	0	
71	4	0-0-0	Hx	4	0	4½	0	
72	3	0-0-0	Hy	10	46	2½	0	
73	3	0-0-0	Hx	31	8	2½	0	
74	3	0-0-0	Hx	14	3	2½	0	